

This application is based on Patent Application No. 2000-267209 filed September 4, 2000, in Japan, the content of which is incorporated hereinto by reference.

5

## BACKGROUND OF THE INVENTION

### FIELD OF THE INVENTION

10

The present invention relates to a cell search method and apparatus for a mobile station in a mobile communication system.

15

### DESCRIPTION OF THE RELATED ART

In a mobile communication system based on the CDMA (Code Division Multiple Access) method, if a mobile station communicates with a base station or measures power received from a base station, it must detect frame boundaries and a scramble code in a down signal from the base station. This is called "cell search".

The cell search method essentially comprises descrambling the signal at all possible scramble codes with all possible timings and selecting a timing and a scramble code with which a correlation coefficient obtained as a

result of despreading with spreading codes used is largest, thereby detecting frame boundaries and the scramble code for the base station. This method, however, requires a large amount of time for the cell search. To increase the speed of the cell search, a method is used in which the base station transmits each slot through a PSCH (Primary Synchronization CHannel) and a SSCH (Secondary Synchronization CHannel) (refer to 3GPP Technical Specification 25.211).

Fig. 1 shows a configuration of a down channel relating to the cell search. This down channel relates to the cell search in the W-CDMA method (refer to 3GPP Technical Specification 25.211), which is representative of the CDMA method. On a primary synchronization channel, a spreading code PSC (Primary Synchronization Code) is used, which is common to all cells and slots, and the signals is transmitted in accordance with slot cycles. On a secondary synchronization channel, different spreading codes  $SSC_0$  to  $SSC_{n-1}$  (Secondary Synchronization Codes) are used for the respective slots, one frame constitutes a spreading code sequence, and is repeatedly and cyclically transmitted. Different spreading code sequences are used for respective cells. The primary and secondary synchronization channels are not subjected to scramble codes. On a common pilot channel (CPICH), the signals is transmitted by using a spreading code and a symbol pattern which are common to all the cells and subjecting the

respective cells to different scramble codes.

Fig. 2 shows a first step operation performed in a conventional cell search method. On the primary synchronization channel, the spreading code PSC, which is common to all the cell and slots, is used. A mobile station inputs a received signal to a matched filter 201 corresponding to this spreading code PSC, and causes an multi-slot averaging section 202 to execute averaging over a plurality of slots in order to reduce the adverse effects of noise and interference. A peak detector 203 selects a timing with which an average correlation coefficient is largest, to detect slot boundaries. This operation is called a "first step".

On the secondary synchronization channel, the different spreading codes are used for the respective slots, and one frame constitutes a spreading code sequence. The spreading code sequence is repeated in accordance with frame cycles, and different spreading code sequences are used for the respective cells. These spreading code sequences are correlated with respective groups of scramble codes so as to allow the scramble codes to be subsequently detected easily. Since the slot boundaries have been detected at the first step, the mobile station can calculate a transmission timing on the secondary synchronization channel.

The mobile station then despreads a received signal using the calculated timing and the spreading codes SSC,

averages correlation output coefficients corresponding to all possible frame boundaries and SSC sequences, and selects a timing and an SSC spreading code sequence with which the average correlation coefficient is largest. The  
5 mobile station thus detects the frame boundaries and a scramble code group. This operation is called a "second step".

Fig. 3 shows a second step operation performed in the conventional cell search method. A timing with which  
10 transmissions is executed on the secondary synchronization channel are calculated on the basis of the slot boundaries detected at the first step. A correlator 301 corresponding to the secondary synchronization codes detects a correlation using the calculated timing. This  
15 operation is performed over a plurality of slots, and the results are averaged by the multi-slot averaging section 302 so as to correspond to possible timings and SSC spreading code sequences. A peak detector 303 detects frame boundaries and a scramble code group by selecting  
20 a timing and an SSC spreading code sequence with which the average correlation coefficient is largest.

The mobile station, which has detected the frame boundaries and the scramble code group during the second step, finally receives the signal, which has been subjected  
25 to a scramble code, through the common pilot channel and determines which of the scramble codes of the scramble code group equals that of the signal. Since the frame

boundaries have already been detected, the phase of the  
scramble code can be calculated. Since the spreading code  
for the common pilot channel is common to all the cells,  
essentially all the scramble codes within the group are  
5 used to descramble the signal, and the spreading code for  
the common primary channel is used to despread the signal.  
Then, these operations are performed over a plurality of  
symbols with the results averaged, and a scramble code is  
selected with which the average correlation coefficient  
10 is largest. This operation is called a "third step".

Fig. 4 shows a third step operation performed in the  
conventional cell search method. A correlator 401  
calculates the phase of the scramble code on the basis of  
the frame boundaries detected at the second step,  
15 descrambles the signal using all the codes of the scramble  
code group detected at the second step, and despreads the  
signal using the spreading code for the common pilot signal.  
A peak detector 403 selects a scramble code with which the  
average correlation coefficient is largest, to detect a  
20 down scramble code used at the base station.

If the first to third steps are defined as one search,  
the mobile station determines whether or not the detected  
frame boundaries and scramble code are correct, after one  
search has been completed. If it has been determined that  
25 they are incorrect, memories for the respective steps are  
initialized, and the search is restarted. This operation  
is repeated until the correct frame boundaries and scramble

code are detected.

Although a propagation path for mobile communication is subject to interference or noise, the signal noise interference power ratio (S/N) of the received signal of the mobile station on the primary synchronization channel, the secondary synchronization channel, or the common pilot channel is generally very small. On the other hand, the cell search is an operation required if the mobile station is to make various measurements for the signal received from the base station, if it is to communicate, or if it is to carry out handover. The search must be executed promptly and accurately in order to reduce the power consumption associated with the mobile communication and ensure a smooth communication. To increase the speed and accuracy of the cell search, the ratio of power transmitted through the down channel for the cell search to the total power transmitted from the base station may be measured. In this case, however, the system capacity disadvantageously decreases.

20

#### SUMMARY OF THE INVENTION

It is an object of the present invention to provide a cell search method for a mobile station in a mobile communication system which does not perform a correlation detecting operation for each step during each search using only an average correlation coefficient for the search but

stores average correlation coefficients for past searches so that both the average correlation coefficient for the present search and the average correlation coefficients for the past searches are used to improve an averaging  
5 effect to increase the detection accuracy of each of the first to third steps, thereby improving the search duration and accuracy.

To attain this object, the present invention provides a method characterized by comprising a first step of  
10 despreadng a received signal using a common spreading code common to all slots and detecting slot boundaries on the basis of a first average correlation coefficient, a second step of despreadng the signal on the basis of the slot boundaries detected at the first step, using different  
15 individual spreading codes for the respective slots, and detecting frame boundaries and a scramble code group on the basis of a second average correlation coefficient, and a third step of descrambling a common pilot signal on the basis of the frame boundaries and scramble code group  
20 detected at the second step, and detecting a scramble code on the basis of a third average correlation coefficient, wherein after the first, second, and third steps have been repeated, the first step is executed to detect slot boundaries using a plurality of the first average  
25 correlation coefficients.

With this method, an average is calculated for a plurality of searches, so that noise and interference can

be more effectively reduced to increase the detection accuracy of the first step.

The second step enables frame boundaries and a scramble code group to be detected using a plurality of  
5 second average correlation coefficients with which equal slot boundaries have been detected at the first step. With this method, average correlation coefficients calculated on the basis of the same slot boundaries are averaged to more effectively reduce noise and interference, thereby  
10 increasing the detection accuracy of the second step.

Further, the present invention provides a method characterized by comprising a first step of despreading a received signal using a common spreading code common to all slots and detecting slot boundaries on the basis of  
15 a first average correlation coefficient, a second step of despreading the signal on the basis of the slot boundaries detected at the first step, using different individual spreading codes for the respective slots, and detecting frame boundaries and a scramble code group on the basis  
20 of a second average correlation coefficient, and a third step of descrambling a common pilot signal on the basis of the frame boundaries and scramble code group detected at the second step, and detecting a scramble code on the basis of a third average correlation coefficient, wherein  
25 after the first, second, and third steps have been repeated, frame boundaries and a scramble code group are detected using a plurality of second average correlation

coefficients with which equal slot boundaries have been detected at the first step.

With this method, only the average correlation coefficients calculated on the basis of the same slot boundaries are averaged to more effectively reduce noise and interference, thereby increasing the detection accuracy of the second step.

The third step enables a scramble code to be detected using a plurality of third average correlation coefficients with which equal frame boundaries and an equal scramble code group have been detected at the second step. With this method, average correlation coefficients calculated on the basis of the same frame boundaries and scramble code group are averaged to more effectively reduce noise and interference, thereby increasing the detection accuracy of the third step.

Furthermore, the present invention provides a method characterized by comprising a first step of despreading a received signal using a common spreading code common to all slots and detecting slot boundaries on the basis of a first average correlation coefficient, a second step of despreading the signal on the basis of the slot boundaries detected at the first step, using different individual spreading codes for the respective slots, and detecting frame boundaries and a scramble code group on the basis of a second average correlation coefficient, and a third step of descrambling a common pilot signal on the basis

of the frame boundaries and scramble code group detected at the second step, and detecting a scramble code on the basis of a third average correlation coefficient, wherein after the first, second, and third steps have been repeated, 5 a scramble code is detected using a plurality of third average correlation coefficients with which equal frame boundaries and an equal scramble code group have been detected at the second step.

With this method, only the average correlation 10 coefficients calculated on the basis of the same frame boundaries and scramble code group are averaged to more effectively reduce noise and interference, thereby increasing the detection accuracy of the third step.

The first step enables a fourth average correlation 15 coefficient to be calculated by averaging a plurality of first average correlation coefficients within a predetermined averaging section so that slot boundaries can be detected using a timing with which the fourth average correlation coefficient is largest. With this method, the 20 average correlation coefficients are averaged within the predetermined averaging section to select a timing with which the average correlation coefficient is largest, thereby enabling slot boundaries to be detected more accurately.

Moreover, the plurality of first average correlation 25 coefficients can be weighted. With this method, the weighting for the averaging can be achieved according to

the temporal distance from the present time, thereby allowing the results of past searches to be used more flexibly.

Furthermore, the fourth average correlation  
5 coefficient can be calculated by the addition of a value obtained by multiplying the plurality of first average correlation coefficients by a forgetting factor. This method enables weighting using older average correlation coefficients even with a small size of memory.

10 The second step enables a fifth average correlation coefficient to be calculated by averaging, within a predetermined averaging section, a plurality of second average correlation coefficients with which equal slot boundaries have been detected at the first step so that  
15 frame boundaries and a scramble code group can be detected using a timing with which the fifth average correlation coefficient is largest. With this method, the average correlation coefficients are averaged within the  
predetermined averaging section to select a timing with  
20 which the average correlation coefficient is largest, thereby enabling frame boundaries and a scramble code group to be detected more accurately.

Moreover, the plurality of second average correlation coefficients can be weighted. With this method, the  
25 weighting for the averaging can be achieved according to the temporal distance from the present time, thereby allowing the results of past searches to be used more

flexibly.

Furthermore, if the slot boundaries detected at the first step are equal, a value is added which is obtained by multiplying a sixth average correlation coefficient  
5 obtained by averaging a plurality of second average correlation coefficients within a predetermined averaging section, by a forgetting factor. If the slot boundaries detected at the first step are different, the result of the addition of the second average correlation  
10 coefficients can be defined as the fifth average correlation coefficient. This method enables weighting using older average correlation coefficients even with a small size of memory.

The third step enables a seventh average correlation  
15 coefficient to be calculated by averaging, within a predetermined averaging section, a plurality of third average correlation coefficients with which equal frame boundaries and an equal scramble code group have been detected at the second step so that the seventh average  
20 correlation coefficient can be used to detect scramble codes. With this method, the average correlation coefficients are averaged within the predetermined averaging section to select a timing with which the average correlation coefficient is largest, thereby enabling  
25 scramble codes to be detected more accurately.

Moreover, the plurality of third average correlation coefficients can be weighted. With this method, the

weighting for the averaging can be achieved according to the temporal distance from the present time, thereby allowing the results of past searches to be used more flexibly.

- 5        Furthermore, if the frame boundaries and scramble code groups detected at the second step are respectively equal, a value can be added which is obtained by multiplying an eighth average correlation coefficient obtained by averaging a plurality of third average correlation
- 10        coefficients within a predetermined averaging section, by a forgetting factor. If the frame boundaries and scramble code groups detected at the second step are respectively different, the result of the addition of the third average correlation coefficients can be defined as the seventh
- 15        average correlation coefficient. This method enables weighting using older average correlation coefficients even with a small size of memory.

- On the other hand, the predetermined averaging section can be adaptively changed according to the state of the
- 20        mobile station. Since the optimal value of the number of averaging sectors depends on the state of the mobile station, this method adaptively changes this value according to the state to enable more efficient cell search.

- 25        Further, the value for the weighting can be adaptively changed according to the state of the mobile station. Since the optimal value for the weighting depends on the

state of the mobile station, this method adaptively changes this value according to the state to enable more efficient cell search.

Furthermore, the value of the forgetting factor can  
5 be adaptively changed according to the state of the mobile station. Since the optimal value of the forgetting factor depends on the state of the mobile station, this method adaptively changes this value according to the state to enable more efficient cell search.

10 The state of the mobile station is either "immediately after power-on" or "standing by" or "communicating". Since the optimal values depend on the state of the mobile station, this method adaptively changes these values according to the state to enable more efficient cell  
15 search.

Further, the state of the mobile station is set in advance according to the movement speed of the mobile station. Since the optimal values depend on the state of the mobile station, this method adaptively changes these  
20 values according to the state to enable more efficient cell search.

According to the present invention, the averaging at each step of the cell search is executed using not only the result of the present search but also the results of  
25 past searches, thereby enabling more accurate search than that in the prior art.

Further, according to the present invention, the

averaging section can be adaptively changed according to the speed of the mobile station or the state thereof including "immediately after power-on", "standing by", and "communicating", thereby achieving more efficient averaging.

The above and other objects, effects, features and advantages of the present invention will become more apparent from the following description of embodiments thereof taken in conjunction with the accompanying drawings.

#### BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a schematic diagram showing a configuration of a down channel relating to cell search;

Fig. 2 is a diagram for use in describing an operation at a first step of a conventional cell search method;

Fig. 3 is a diagram for use in describing an operation at a second step of the conventional cell search method;

Fig. 4 is a diagram for use in describing an operation at a third step of the conventional cell search method;

Fig. 5 is a diagram for use in describing an operation at a first step of a cell search method according to one embodiment of the present invention;

Fig. 6 is a diagram showing a multi-search averaging method executed at the first step of the cell search method

according to the embodiment of the present invention;

Fig. 7 is a diagram showing a method of executing the multi-search averaging at the first step using a forgetting factor;

5 Fig. 8 is a diagram for use in describing an operation at a second step of a cell search method according to the embodiment of the present invention;

Fig. 9 is a diagram showing a multi-search averaging method executed at the second step of the cell search method according to the embodiment of the present invention;

Fig. 10 is a diagram showing a method of executing the multi-search averaging at the second step using a forgetting factor;

Fig. 11 is a diagram for use in describing an operation at a third step of a cell search method according to the embodiment of the present invention;

Fig. 12 is a diagram showing a multi-search averaging method executed at the third step of the cell search method according to the embodiment of the present invention; and

20 Fig. 13 is a diagram showing a method of executing the multi-search averaging at the third step using a forgetting factor.

#### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

25

An embodiment of the present invention will be described below in detail with reference to the drawings.

Fig. 5 shows an operation at a first step of a cell search method according to the embodiment of the present invention. On a primary synchronization channel, a spreading code PSC common to all cells and slots is used. A mobile station  
5 inputs a received signal to a matched filter 501 corresponding to this spreading code PSC, and a multi-slot averaging section 502 executes averaging over a plurality of slots in order to reduce noise or interference. In contrast to the conventional method, after the averaging  
10 over the plurality of slots, a multi-search averaging section 504 executes averaging over a plurality of searches. Subsequently, the peak detector 203 selects a timing with which the average correlation coefficient is largest, to detect slot boundaries. The averaging over the plurality  
15 of searches more effectively reduces noise and interference to increase the detection accuracy of the first step.

Fig. 6 shows a method of multi-search averaging executed at the first step of the cell search method  
20 according to the embodiment of the present invention. The mobile station inputs a received signal to a matched filter 601 corresponding to the spreading code PSC, and a multi-slot averaging section 602 executes the averaging. The result of the averaging over the plurality of slots  
25 is stored in overwrite memories  $604_1$  to  $604_{N-1}$ . In this manner, the results of past searches are stored, and a total of seven results including the one of the present search

are averaged by an average value calculating section 605. A peak detector 603 then selects a timing with which the average correlation coefficient is largest, thereby enabling slot boundaries to be detected more accurately.

5        Since the slot boundary temporally varies due to the movement of the mobile station or the like, N may be properly set so that the multi-search averaging is executed only for a range within which the variation is small. Further, for the averaging, the results of the past  
10 searches can be more flexibly used by executing the weighting according to the temporal distance from the present time ( $W_0, W_1$  to  $W_{N-1}$ ).

Fig. 7 shows a method of executing the multi-search averaging at the first step using a forgetting factor. The  
15 mobile station inputs a received signal to a matched filter 701 corresponding to the spreading code PSC, and a multi-slot averaging section 702 executes the averaging. The result of the averaging over the plurality of slots is multiplied by a forgetting factor  $\lambda$  ( $0 \leq \lambda \leq 1$ ), and the  
20 result of the multiplication is added to an additive memory 704. The present result and the past results stored in the additive memory 704 are averaged by an average-value calculating section 705. A peak detector 703 selects a  
25 largest, to detect slot boundaries. For the multi-search averaging, the larger the forgetting factor  $\lambda$  is, the older results can be used. This method advantageously

requires only a small-sized memory.

Fig. 8 shows an operation at a second step of the cell search method according to the embodiment of the present invention. A timing with which transmissions are executed  
5 on the secondary synchronization channel is calculated from the slot boundaries detected at the first step. A correlator 801 corresponding to secondary synchronization codes SSC detects a correlation using the calculated timing. This operation is performed over a plurality of slots, and  
10 the results are averaged by a multi-slot averaging section 802 so as to correspond to possible timings and SSC spreading code sequences. In contrast to the conventional method, not only the averaging is executed over the plurality of slots for the present search but a multi-  
15 search averaging section 804 also executes averaging over a plurality of searches. Further, the peak detector 803 selects a timing and an SSC sequence with which the average correlation coefficient is largest, to detect slot boundaries.

20 However, for the multi-search averaging are used only the slot boundaries detected at the first step of the present search and the average correlation coefficient obtained at the second step from searches in which the same slot boundaries have been detected. That is, average  
25 correlation coefficients calculated on the basis of different slot boundaries are not averaged. With this method, noise and interference can be more effectively

reduced to increase the detection accuracy of the second step.

Fig. 9 shows a method of executing the multi-search averaging at the second step of the cell search method according to the embodiment of the present invention. A timing with which transmissions are executed on the secondary synchronization channel is calculated from the slot boundaries detected at the first step. A correlator 901 corresponding to the secondary synchronization codes SSC detects a correlation using the calculated timing. This operation is performed over a plurality of slots, and the results are averaged by a multi-slot averaging section 902 so as to correspond to possible timings and SSC spreading code sequences. The result of the averaging over the plurality of slots is stored in overwrite memories 904<sub>1</sub> to 904<sub>N-1</sub>. In this manner, the results of past searches are stored, and a maximum of N results including the one of the present search are averaged by an average-value calculating section 905. A peak detector 903 then selects a timing and an SSC sequence with which the average correlation coefficient is largest, thereby enabling frame boundaries and a scramble code group to be detected more accurately.

Since the frame boundary temporally varies due to the movement of the mobile station or the like, N may be properly set so that the multi-search averaging is executed only for a range within which the variation is small.

Further, for the averaging, the results of the past searches can be more flexibly used by executing the weighting according to the temporal distance from the present time ( $W_0, W_1$  to  $W_{N-1}$ ).

- 5        However, for the multi-search averaging are used only the slot boundaries detected at the first step of the present search and the average correlation coefficient obtained at the second step from searches in which the same slot boundaries have been detected. In Fig. 9, a control
- 10   section 906 monitors and stores the slot boundaries detected at the first step of each search and selects some of them for the averaging. Alternatively, similar effects are obtained by the control section 906 by controlling the weighting values ( $W_0, W_1$  to  $W_{N-1}$ ).
- 15   Fig. 10 shows a method of executing the multi-search averaging at the second step using a forgetting factor. A timing with which transmissions is executed on the secondary synchronization channel are calculated from the slot boundaries detected at the first step. A correlator
- 20   1001 corresponding to the secondary synchronization codes SSC detects a correlation using the calculated timing. This operation is performed over a plurality of slots, and the results are averaged by a multi-slot averaging section 1002 so as to correspond to possible timings and SSC
- 25   spreading code sequences. The result of the averaging over the plurality of slots is multiplied by a forgetting factor  $\lambda$  ( $0 \leq \lambda \leq 1$ ), and the result of the multiplication is added

to an additive memory 1004. The present result and the past results stored in the additive memory 1004 are averaged by an average-value calculating section 1005. A peak detector 1003 selects a timing with which the average correlation coefficient is largest, to detect slot boundaries.

For the multi-search averaging, the larger the forgetting factor  $\lambda$  is, the older results can be used. This method advantageously requires only a small-sized memory. Further, if the slot boundaries detected at the first step are different from the slot boundaries detected during the preceding search, then the control section 1006 resets the contents of the memory to avoid averaging average correlation coefficients for different timings which have been obtained at the second step.

Fig. 11 shows an operation at a third step of the cell search method according to the embodiment of the present invention. A correlator 1101 calculates the phase of the scramble code on the basis of the frame boundaries detected at the second step, descrambles the signal using all the codes of the scramble code group detected at the second step, and despreads the signal using the spreading code for the common pilot channel. This operation is performed over a plurality of slots, and the results are averaged by a multi-symbol averaging section 1102. In contrast to the conventional method, not only the averaging is executed over the plurality of symbols for the present search but

a multi-search averaging section 1104 also executes averaging over a plurality of searches. The peak detector 403 selects a scramble code with which the average correlation coefficient is largest, to detect a down  
5 scramble code used for the base station.

However, for the multi-search averaging are used only the average correlation coefficient obtained at the third step of searches in which the same frame boundaries and scramble code group as those in the present search have  
10 been detected at the second step. That is, average correlation coefficients calculated on the basis of different frame boundaries or scramble code groups are not averaged. With this method, noise and interference can be more effectively reduced to increase the detection  
15 accuracy of the third step.

Fig. 12 shows a method of executing the multi-search averaging at the third step of the cell search method according to the embodiment of the present invention. A correlator 1201 calculates the phase of the scramble code  
20 on the basis of the frame boundaries detected at the second step, descrambles the signal using all the codes of the scramble code group detected at the second step, and despreads the signal using the spreading code for the common pilot channel. This operation is performed over  
25 a plurality of symbols, and the results are averaged by a multi-symbol averaging section 1202. The result of the averaging over the plurality of symbols is stored in

overwrite memories 1204<sub>1</sub> to 1204<sub>N-1</sub>. In this manner, the results of past searches are stored, and a maximum of N results including the one of the present search are averaged by an average-value calculating section 1205. A  
5 peak detector 1203 then selects a scramble code with which the average correlation coefficient is largest, thereby detecting the scramble code more accurately.

Since the frame boundary temporally varies due to the movement of the mobile station or the like, N may be  
10 properly set so that the multi-search averaging is executed only for a range within which the variation is small. Further, for the averaging, the results of the past searches can be more flexibly used by executing the weighting according to the temporal distance from the  
15 present time ( $W_0, W_1$  to  $W_{N-1}$ ).

However, for the multi-search averaging are used only the average correlation values obtained at the third step of searches in which the same frame boundaries and scramble code group as those in the present search have been detected  
20 at the second step. In Fig. 12, a control section 1206 monitors and stores the frame boundaries and scramble detected at the second of each search and selects some of them for the averaging. Alternatively, similar effects are obtained by the control section 1206 by controlling  
25 the weighting values ( $W_0, W_1$  to  $W_{N-1}$ ).

Fig. 13 shows a method of executing the multi-search averaging at the third step using a forgetting factor. A

correlator 1301 calculates the phase of the scramble code on the basis of the frame boundaries detected at the second step, descrambles the signal using all the codes of the scramble code group detected at the second step, and  
5 despreads the signal using the spreading code for the common pilot channel. This operation is performed over a plurality of symbols, and the results are averaged by a multi-symbol averaging section 1302. The result of the averaging over the plurality of symbols is multiplied by  
10 a forgetting factor  $\lambda$  ( $0 \leq \lambda \leq 1$ ), and the result of the multiplication is added to an additive memory 1304. The present result and the past results stored in the additive memory 1304 are averaged by an average-value calculating section 1305. A peak detector 1003 selects a timing with  
15 which the average correlation coefficient is largest, to detect slot boundaries.

For the multi-search averaging, the larger the forgetting factor  $\lambda$  is, the older results can be used. This method advantageously requires only a small-sized  
20 memory. Further, if the frame boundaries and scramble code group detected at the second step are different from those detected during the preceding search, then the control section 1306 resets the contents of the memory to avoid averaging those average correlation coefficients for  
25 different timings or scramble code groups which have been obtained at the third step.

The optimal value of the number of memories used for

the averaging, the weighting, or the forgetting factor depends on the movement speed of the mobile station or the like. Thus, the cell search can be more effectively executed by adaptively changing these values according to the movement speed or the like.

Further, when, for example, the power to the mobile station is turned on, a clock of the mobile station is unstable. Accordingly, the averaging section must be shortened. Also during a standby period, the clock is so unstable that a current consumption problem may occur, so that the averaging section must be shortened. In this manner, the cell search can be more effectively executed by changing the number  $N$  of memories used for the averaging, the weighting value ( $W_0, W_1$  to  $W_{N-1}$ ), or the forgetting factor value  $\lambda$  ( $0 \leq \lambda \leq 1$ ) according to the state of the mobile station.

The present invention has been described in detail with respect to preferred embodiments, and it will now be apparent from the foregoing to those skilled in the art that changes and modifications may be made without departing from the invention in its broader aspects, and it is the intention, therefore, in the appended claims to cover all such changes and modifications as fall within the true spirit of the invention.